Attachment B. Questionnaire submitted to biologists with expertise in biology and ecology of freshwater mussels, July 1994.

Effects of Commercial Navigation Traffic
Environmental Modeling

U.S. Army Corps of Engineers, Louisville District,

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Background Information

Introduction

The Louisville District, U.S. Army Corps of Engineers has been developing methods to assess the environmental effects of commercial navigation traffic since 1985. One of these efforts has led to a development of the Navigation Predictive Analysis Technique (NAVPAT), a habitat-based methodology that provides an incremental analysis of tow passage on navigable waterways. This methodology draws on the basic concept of Habitat Evaluation Procedures (HEP) and Instream Flow Incremental Methodology (IFIM), two techniques used to assess changes to terrestrial and aquatic habitat from man's actions. As initiated with HEP and IFIM, NAVPAT continues the use of biological models with suitability indices and accounts for pulsation-type alterations common with movement of large commercial vessels. The efforts to develop and refine NAVPAT have been directed to large navigable rivers such as the Ohio River but the model has been successfully applied to rivers as small as the Green River in Kentucky.

Need for Models

Present U.S. Army Corps of Engineers policy requires use of habitat based methods for impact assessment if mitigation is to be a part of a recommended project plan that requires review and approval by higher headquarters. It is anticipated that this requirement will continue in the foreseeable future as examinations of mitigation determine both "cost effectiveness" of proposed mitigation measures and "incremental analysis" to ascertain whether partial, full, or more than full mitigation is represented by project plans.

Need For Additional Indicator Models

Fifteen biological species life-stage models have been developed as part of the overall NAVPAT model. These models reflect a group of species that individually use particular types of riverine habitat at various points in their life. The species life-stage groupings were based on a guilding process of available habitat and habitat usage by varying stages of fishes as they mature to adults. A number of these models account for effects of commercial traffic on habitat suitability based on modifications to physical habitat such as substrate disturbance or velocity pulses that may dislodge organisms. Alteration of available habitat by entrainment of organisms through the volume surrounding towboat propellers and/or subjecting organisms to significant levels of shear and turbulence are also considered in some of the NAVPAT biological models.

These models only address a portion of the present aquatic community and do not directly address the assemblage of freshwater mussels found in navigable rivers, in particular those that occupy stable gravel bar habitat. Because these organisms are both ecologically and economically significant, it has been determined that an effort should be made to develop one or more models for inclusion into the NAVPAT program. Although riverine mussels also occupy areas that are dominated by fine-grained sediments, it has been determined that the first effort will focus on those that typically occupy the coarse, stable substrate areas. The vulnerability or extent of potential impact to these organisms from commercial navigation traffic is not known. The effort to develop the model(s) will, in part, help describe those linkages from the hydrodynamic forces caused by moving tows that may affect these organisms.

Habitat Suitability Criteria for Native Unionid Mussels

Purpose: To quantify effects of commercial navigation traffic on habitat suitability for gravel-bar mussels. Specifically, to allow *comparison of alternative navigation-traffic scenarios* in terms of effects on gravel bar mussel beds.

Approach: Criteria need to be sensitive to potential effects on mussels, based on best available information, and amenable to testing. Biologists knowledgeable in life history and ecology of gravel bar mussels will be asked to describe the vertical profile of mussels within a "typical" gravel bar, for species occurring in the Ohio River. Biologists will be asked to specify known differences among species in their vertical distribution within gravel bars, and to describe known or suspected ontogenetic changes in the depth to which individuals bury. Secondly, biologists will be asked to estimate mortality rates for mussels that become dislodged from the substrate (e.g., by a surge in current velocity created by a passing tow), and to specify known or suspected differences in dislodgment-related mortality among species or size-classes.

Effects of commercial navigation traffic on habitat suitability for mussels at a particular location will be estimated on the basis of information provided by knowledgeable biologists. Specifically, given (1) the vertical profile of mussel distribution within a gravel bar, (2) the depth to which a passing tow disturbs the substrate, and (3) an estimated mortality rate for displaced mussels, then the reduction in habitat suitability for mussels at that point, for a single tow-related disturbance, will be estimated as the proportion of the population disturbed multiplied by the estimated mortality rate. The cumulative effect of repeated passing tows over a specific location on a mussel bed will be estimated by summing successive reductions in habitat suitability at that point through time. As possible, given available information, effects on habitat suitability for different species and size-classes of mussels will be separately estimated.

Assumptions:

(1) A passing tow may create a surge in current velocity that extends nearly uniformly from top to bottom of the water column. The velocity surge may move bed material and embedded mussels. The depth to which the substrate and embedded mussels are disturbed depends on how much the velocity surge increases shear stress at the substrate.

(2) Substrate displacement is an appropriate response variable for assessing effects of commercial navigation traffic on habitat suitability for gravel bar mussels.

a. Tows are assumed not to run aground on mussel beds in normal operation areas of waterways.

b. Additional siltation on existing gravel-bar mussel beds is assumed not to be a problem as long as flow patterns remain the same.

c. Effects on disruption of feeding or reproductive activities resulting from velocity surges that are not strong enough to displace substrate and embedded mussels are not considered.

d. Effects of velocity surges on habitat suitability for host fishes also are not considered.

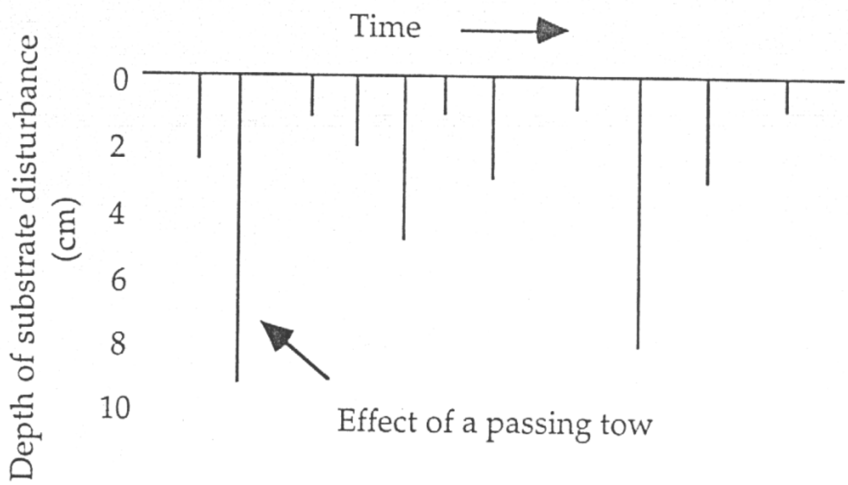
(3) The effect of substrate movement on mussels depends on the proportion of the mussel population (or size-class, or assemblage if species are not considered separately) occurring in the layer of substrate that is displaced, and on the mortality rate for mussels that are dislodged during a substrate-displacement event. Displaced substrate and mussels are assumed to resettle immediately following passage of a tow.

(4) Mussel assemblages include individuals across a wide range of sizes. Recently settled (juvenile) mussels may be present during every month of the year because of variable reproductive periods within an assemblage.

(5) For a given navigation traffic scenario, NAVPAT can simulate for a particular area of a mussel bed:

- the number and frequency of passing tows and the forces generated by each tow
- the depth to which the gravel-sand matrix composing the bed is disturbed by each tow.

This results in a time-series of substrate disturbance events, estimated for known locations of mussel beds.



In this diagram, each vertical line shows the depth of substrate disturbance (in cm) caused by a passing tow at a particular location in the river. The time series can thus be used to quantify the intensity (depth) and frequency of substrate disturbance for a given navigation scenario.

Criteria Development

In the absence of empirical data on the tolerance of mussels to this type of disturbance, expert or informed opinion is required to estimate relative effects of disturbing the substrate to a given depth on habitat value. We propose developing criteria through a Delphi technique. Participating experts are asked to provide preliminary descriptions of the vertical distribution of mussels within gravel-bar beds, and as possible to indicate species- or size-related differences in vertical distribution. Experts are also asked to estimate rates of mortality for dislodged mussels, indicating differences among species or mussel size-classes as appropriate. Finally, experts are asked to suggest other habitat factors that should be included in the models (e.g., should different models be developed for different seasons?). We will summarize responses to this initial questionnaire as a set of preliminary sketches of the vertical profile of mussel distribution within gravel-bar beds, and estimated mortality rates for dislodged individuals, and send these back to the experts for review. Each expert will be asked to indicate agreement or disagreement with preliminary descriptions of vertical distribution and estimated mortality rates, to modify descriptions and mortality estimates as appropriate, and to provide supporting arguments or information. We will summarize results of this second round of questioning, and redistribute modified profile descriptions and mortality estimates with supporting information for reconsideration by the experts. We will continue this iterative process until at least 75% of the experts agree with the vertical profile descriptions and mortality estimates.

Criteria Testing

Any set of habitat suitability models, regardless of how much data they may be based on, should be tested with respect to their ability to predict real effects of habitat alteration on populations. We recognize the importance of field-testing the criteria developed in this exercise as data become available describing mussel densities, size or age-class structures, and species compositions in beds presently experiencing various degrees of barge traffic. For example, criteria could be used to predict habitat suitability for different parts of a gravel bar mussel bed experiencing a gradient of tow-traffic effects (i.e., from most disturbed by commercial navigation to least disturbed). If the criteria provide adequate estimates of navigation traffic effects on mussel habitat suitability, then mussel abundances and size-distributions should correspond to predicted habitat suitability. Until criteria in this exercise can be tested, it is U.S. Fish and Wildlife Service policy that their use be accompanied by a statement that the criteria are based on best available data and opinion, but are untested.

Preliminary Criteria Development

This represents the first round of criteria development, in which the goals are to produce preliminary estimates of the vertical distribution of mussels within gravel-bar beds, and of the probability of mortality for mussels dislodged from the substrate by a velocity surge created by a passing tow.

Species Involved

The following native unionid mussel species may occur in gravel-bar beds of the Ohio River (approx. River Miles 939 - 981):

Lasmigona complanata (Barnes, 1823)	White heelsplitter
Megalonaias nervosa (Rafinesque, 1820)	Washboard
Tritogonia verrucosa (Rafinesque, 1820)	Buckhorn
Quadrula quadrula (Rafinesque, 1820)	Mapleleaf
Quadrula cylindrica (Say, 1817)	Rabbitsfoot
Quadrula metanevra (Rafinesque, 1820)	Monkeyface
Quadrula nodulata (Rafinesque, 1820)	Wartyback

Quadrula p. pustulosa (Lea, 1831)	Pimpleback
Amblema p. plicata (Say, 1817)	Threeridge
Fusconaia ebena (Lea, 1831)	Ebonyshell
Fusconaia flava (Rafinesque, 1820)	Pigtoe
Pleurobema cordatum (Rafinesque, 1820)	Ohio pigtoe
Cyclonaias tuberculata (Rafinesque, 1820)	Purple wartyback
Plethobasus cooperianus (Lea, 1834)	Orange-foot pimpleback
Plethobasus cyphyus (Rafinesque, 1820)	Bullhead
Elliptio c. crassidens (Lamarck, 1819)	Elephant-ear
Obliquaria reflexa Rafinesque, 1820	Threehorn wartyback
Ellipsaria lineolata (Rafinesque, 1820)	Butterfly
Obovaria olivaria (Rafinesque, 1820)	Hickorynut
Truncilla truncata Rafinesque, 1820	Deertoe
Truncilla donaciformis (Lea, 1828)	Fawnsfoot
Toxolasma parvus (Barnes, 1823)	Lilliput
Leptodea fragilis (Rafinesque, 1820)	Fragile papershell
Potamilus alatus (Say, 1817)	Pink heelsplitter
Ligumia recta (Lamarck, 1819)	Black sandshell
Lampsilis teres f.teres (Rafinesque, 1820)	Slough sandshell
Lampsilis teres f.anodontoides (Lea, 1831)	Yellow sandshell
Lampsilis ovata (Say, 1817)	Pocketbook

Vertical Distributions

Ohio River gravel-bar mussel beds have a dominant bed material of 3-6 cm diameter gravel. Please consider the species involved (listed above), and give your best estimates of the proportions of mussel populations expected to occur at various depths in a gravel-bar bed, as follows:

1. What is the depth into the gravel-bar substrate above which you would expect nearly all (i.e., 99% of all individuals) of the mussel assemblage to occur?

2. Would you expect species, or groups of similar species, to differ in their vertical distributions within a gravel-bar?

3. Would you expect differences among size-classes of mussels in their vertical distributions within a gravel-bar?

If you answered "No" to questions 2 and 3 - Estimate the proportion of the mussel assemblage you would expect to occur at increasing depth into the gravel-bar substrate, up to the maximum depth indicated in your answer to question 1. The mussel proportions should sum to 1 (or at least to .99, representing 99%):

Depth into the gravel substrate	Proportion of the mussel assemblage
0 to 1 cm	
> 1 to 2 cm	
> 2 to 3 cm	
> 3 to 4 cm	
> 4 to 5 cm	
> 5 to 6 cm	
> 6 to 7 cm	
> 7 to 8 cm	
> 8 to 9 cm	
> 9 to 10 cm	
> 10 to 11 cm	
> 11 to 12 cm	
> 12 to 13 cm	
> 13 to 14 cm	
> 14 to 15 cm	
(continue to maximum depth as indicated in question 1)	

If you answered"No" to question 2 (i.e., no significant differences among species) but "Yes" to question 3 - Estimate the proportion of distinct mussel size-classes you would expect to occur at increasing depth into the gravel-bar substrate, up to the maximum depth indicated in your answer to question 1. Please use extra pages if you wish to show distributions for more than three different mussel size-classes. The proportions for each size-class should sum to 1 (or at least to .99, representing 99%):

Depth into the gravel substrate	Proportion of each mussel size-class Size-class (range in lengths)		
	___-___ cm	___-___ cm	___-___ cm
0 to 1 cm			
> 1 to 2 cm			
> 2 to 3 cm			
> 3 to 4 cm			
> 4 to 5 cm			
> 5 to 6 cm			
> 6 to 7 cm			
> 7 to 8 cm			
> 8 to 9 cm			
> 9 to 10 cm			
> 10 to 11 cm			
> 11 to 12 cm			
> 12 to 13 cm			
> 13 to 14 cm			
> 14 to 15 cm			
(continue to maximum depth as indicated in question 1)			

If you answered "Yes" to questions 2 and 3 - Estimate the proportion of the individuals for each species, or group of species, and for individual size-classes for each species or species-group, you would expect to occur at increasing depth into the gravel-bar substrate, up to the maximum depth indicated in your answer to question 1. Please make extra pages as needed to show distributions for additional species/species groups or for more than three different mussel size-classes. The proportions for each size-class within each species/species-group should sum to 1 (or at least to .99, representing 99%):

Species (indicate the species for which the following depth-distributions apply):

Depth into the gravel substrate	Proportion of each mussel size-class Size-class (range in lengths)		
	___-___ cm	___-___ cm	___-___ cm
0 to 1 cm			
> 1 to 2 cm			
> 2 to 3 cm			
> 3 to 4 cm			
> 4 to 5 cm			
> 5 to 6 cm			
> 6 to 7 cm			
> 7 to 8 cm			
> 8 to 9 cm			
> 9 to 10 cm			
> 10 to 11 cm			
> 11 to 12 cm			
> 12 to 13 cm			
> 13 to 14 cm			
> 14 to 15 cm			
(continue to maximum depth as indicated in question 1)			

Species (indicate the species for which the following depth-distributions apply):

Depth into the gravel substrate	Proportion of each mussel size-class Size-class (range in lengths)		
	___-___ cm	___-___ cm	___-___ cm
0 to 1 cm			
> 1 to 2 cm			
> 2 to 3 cm			
> 3 to 4 cm			
> 4 to 5 cm			
> 5 to 6 cm			
> 6 to 7 cm			
> 7 to 8 cm			
> 8 to 9 cm			
> 9 to 10 cm			
> 10 to 11 cm			
> 11 to 12 cm			
> 12 to 13 cm			
> 13 to 14 cm			
> 14 to 15 cm			
(continue to maximum depth as indicated in question 1)			

Species (indicate the species for which the following depth-distributions apply):

Depth into the gravel substrate	Proportion of each mussel size-class Size-class (range in lengths)		
	___-___ cm	___-___ cm	___-___ cm
0 to 1 cm			
> 1 to 2 cm			
> 2 to 3 cm			
> 3 to 4 cm			
> 4 to 5 cm			
> 5 to 6 cm			
> 6 to 7 cm			
> 7 to 8 cm			
> 8 to 9 cm			
> 9 to 10 cm			
> 10 to 11 cm			
> 11 to 12 cm			
> 12 to 13 cm			
> 13 to 14 cm			
> 14 to 15 cm			
(continue to maximum depth as indicated in question 1)			

Mortality Rates

In the NAVPAT procedure, substrate (and mussels) dislodged and suspended into the water column by a velocity surge created by a passing tow are assumed to resettle in the same vicinity immediately following passage of a tow.

1. Would you expect differences among species in the probability of mortality for an individual that was dislodged from its position in the substrate and then re-deposited?

2. Would you expect differences among different mussel size-classes in the probability of mortality for an individual that was dislodged from its position in the substrate and then re-deposited?

If you answered "No" to questions 1 and 2 - Estimate the overall probability that an individual mussel will not recover and successfully re-bury in to the substrate following dislodgment and possible brief suspension in the water column:

If you answered "No" to question 1 (i.e., no significant differences among species) but "Yes" to question 2- - Estimate the probability that an individual mussel in each appropriate size-class will not recover and successfully re-bury in to the substrate following dislodgment and possible brief suspension in the water column:

Size-class (length range in cm)	Probability of mortality

If you answered "Yes" to questions 1 and 2 - Estimate the probability that an individual mussel, in each appropriate size-class and species or species-group, will not recover and successfully re-bury in to the substrate following dislodgment and possible brief suspension in the water column (please use additional pages as necessary to show mortality estimates for additional species or species groups):

Species (indicate the species for which the following mortality probabilities apply):

<u>Size-class (length range in cm)</u>	<u>Probability of mortality</u>

Species (indicate the species for which the following mortality probabilities apply):

<u>Size-class (length range in cm)</u>	<u>Probability of mortality</u>

Other considerations

Should separate vertical profiles of mussel distributions in the substrate be developed for different seasons? If so, indicate seasonal changes on the above profiles or construct new profiles for different seasons.

Should mortality rates for mussels dislodged from the substrate be estimated separately for different seasons? Again, if so please indicate suspected seasonal-differences in mortality probabilities on the preceeding sheets.

Finally, do you have other comments or suggestions regarding the appropriateness of estimating effects of commercial traffic on habitat suitability of gravel-bar mussels by examining vertical profiles of mussels in the substrate and mussel mortality resulting from dislodgment? For example:

- Would you expect large differences among mussel species that differ in shape or shell-characteristics in their susceptibility to dislodgment by velocity surges?

- Should species differences in vulnerability to velocity surges be incorporated in assessments by NAVPAT (as opposed to assuming that <u>all</u> mussels occurring to a given depth in the substrate are dislodged by a velocity surge that moves the gravel substrate to that depth)?